Chart 10
PCS Basic Trading Areas—BTAs
As defined by Rand McNally's Commercial Atlas & Marketing Guide

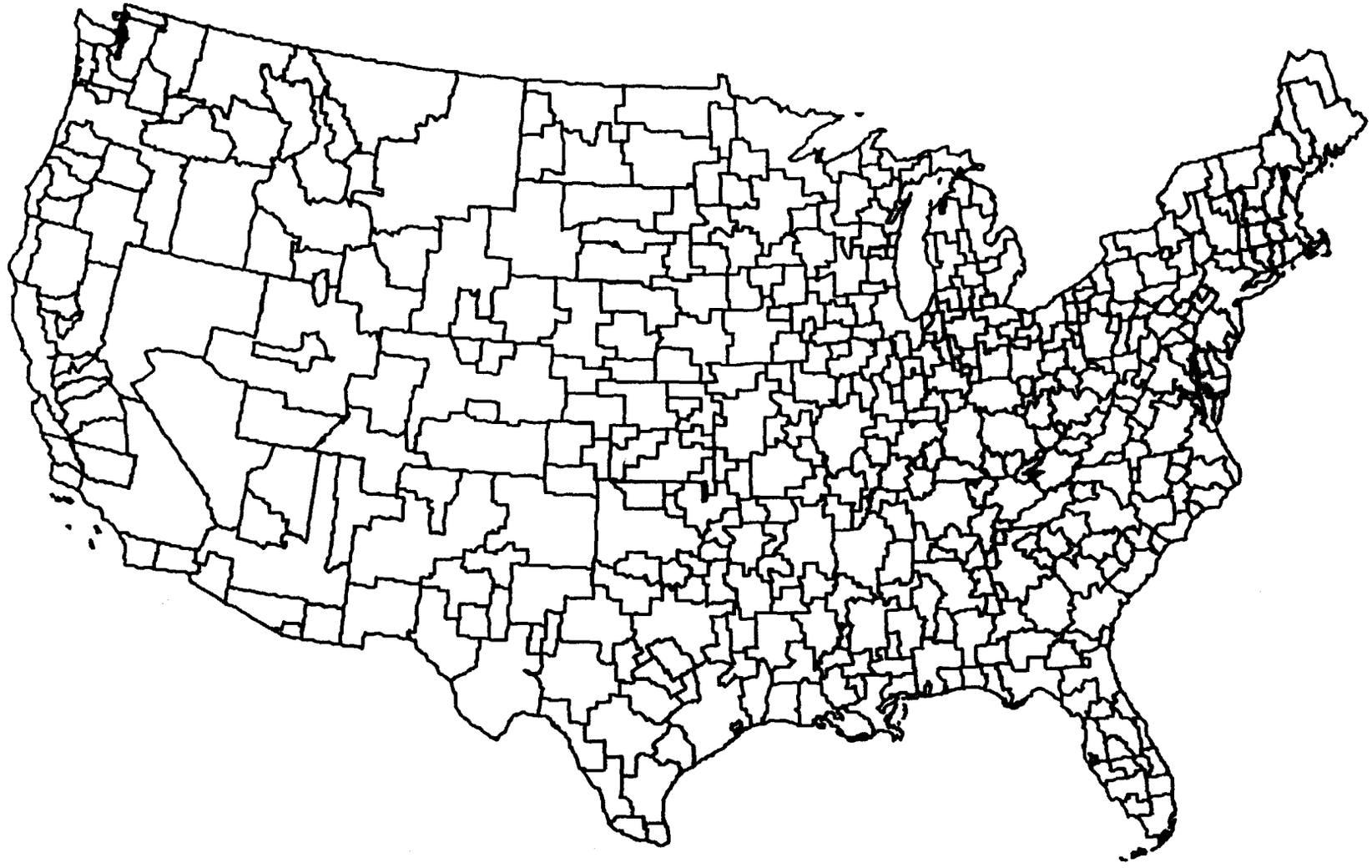


Table 4
Demographic Data on the 51 Major Trading Areas

MTA	MTA Name	1990 POPs	Total Households	Households >$50K Inc.	Avg. HH Income	Pop. Density	Square Miles
1	New York	26,410,597	9,770,700	2,920,191	34,216	421	62,661
2	Los Angeles-San Diego	19,145,232	6,701,500	1,984,834	33,142	159	120,345
3	Chicago	12,069,703	4,415,000	1,092,585	31,778	265	45,467
4	San Francisco-Oakland-San Jose	11,891,177	4,405,900	1,306,719	33,828	81	146,164
5	Detroit	10,001,009	3,685,900	727,430	29,017	202	49,479
6	Charlotte-Greensboro-Greenville-Raleigh	9,752,317	3,678,700	502,705	23,938	133	73,076
7	Dallas-Fort Worth	9,694,157	3,630,900	666,499	25,852	45	215,618
8	Boston-Providence	9,452,712	3,562,700	929,991	32,181	187	50,625
9	Philadelphia	8,927,748	3,315,000	828,325	31,521	451	19,784
10	Washington-Baltimore	7,777,875	4,155,100	1,516,229	39,849	330	23,584
11	Atlanta	6,942,084	2,588,200	501,408	26,901	119	58,116
12	Minneapolis-St. Paul	5,986,039	2,268,300	403,638	27,296	28	216,471
13	Tampa-St. Petersburg-Orlando	5,417,788	2,261,000	397,214	25,087	321	16,904
14	Houston	5,190,849	1,879,000	388,705	28,693	130	39,799
15	Miami-Fort Lauderdale	5,136,581	2,077,900	481,240	27,976	367	14,010
16	Cleveland	4,945,749	1,870,700	334,045	27,991	385	12,839
17	New Orleans-Baton Rouge	4,925,269	1,763,300	280,278	23,996	106	46,634
18	Cincinnati-Dayton	4,716,665	1,773,200	280,738	25,644	153	30,816
19	St. Louis	4,663,926	1,778,700	308,995	26,014	78	59,991
20	Milwaukee	4,541,432	1,701,900	311,900	28,790	91	49,906
21	Pittsburgh	4,102,766	1,587,900	232,413	25,385	179	22,890
22	Denver	3,880,637	1,509,200	294,626	28,301	17	222,349
23	Richmond-Norfolk	3,846,210	1,442,100	257,380	27,040	137	28,104
24	Seattle	3,827,175	1,693,100	426,805	31,493	-	-
25	Puerto Rico - U.S Virgin Islands	3,623,846	-	-	-	-	-

Table 4
Demographic Data on the 51 Major Trading Areas continued

MTA	MTA Name	1990 POPs	Total Households	Households >$50K Inc.	Avg. HH Income	Pop. Density	Square Miles
26	Louisville-Lexington-Evansville	3,556,648	1,347,400	169,766	22,369	91	38,976
27	Phoenix	3,510,140	1,343,300	232,252	25,871	38	93,498
28	Memphis-Jackson	3,465,226	1,248,800	161,969	20,870	64	54,070
29	Birmingham	3,244,076	1,221,100	161,708	22,079	83	38,964
30	Portland	3,059,948	1,195,300	189,184	26,060	38	81,237
31	Indianapolis	3,017,475	1,144,300	178,864	25,956	140	21,597
32	Des Moines-Quad Cities	3,006,139	1,147,000	168,921	25,625	52	57,545
33	San Antonio	2,986,524	976,200	123,087	21,124	65	45,953
34	Kansas City	2,913,304	1,125,200	205,435	26,635	69	42,212
35	Buffalo-Rochester	2,777,046	1,050,100	206,110	28,796	201	13,839
36	Salt Lake City	2,573,372	844,300	128,927	26,223	16	159,516
37	Jacksonville	2,274,960	862,200	146,146	23,908	79	28,880
38	Columbus	2,145,561	812,200	122,347	25,306	163	13,174
39	El Paso-Albuquerque	2,113,790	728,500	95,290	21,893	15	143,392
40	Little Rock	2,051,667	787,000	92,378	21,020	47	43,949
41	Oklahoma City	1,877,478	714,100	79,703	21,336	44	42,674
42	Spokane-Billings	1,863,335	709,900	99,182	24,322	9	210,846
43	Nashville	1,767,391	672,400	114,052	25,488	98	18,090
44	Knoxville	1,721,911	665,700	86,016	22,259	115	14,935
45	Omaha	1,659,273	634,300	103,467	25,788	24	68,326
46	Wichita	1,124,174	433,500	69,946	26,028	19	58,873
47	Honolulu	1,108,229	360,000	115,393	35,254	173	6,413
48	Tulsa	1,096,396	427,000	52,321	22,342	76	14,521
49	Alaska	550,043	-	-	-	-	-
50	Guam - Northern Mariano Islands	176,000	-	-	-	-	-
51	American Samoa	47,000	-	-	-	-	-
Totals (Average for HH Income)		252,556,649	93,965,700		26,861		2,937,112

Table 5
Designated Entity Bidding Credits, Installment Payments and Tax Benefits

Type of Designated Entity	Bidding Credit	Installment Payments	Tax Certificates For Investors
Entrepreneurial Business ($40 MM - $125 MM in revenue and <$500 in total assets)	0%	Interest only for 1 year; rate equal to 10-year Treasury note plus 2.5%; (for businesses with revenues greater $75 MM, available only in top 50 mkts.)	No
Small Business (<$40 MM in revenues)	10%	Interest only for 2 years; rate equal to 10-year Treasury note plus 2.5%	Yes
Business Owned by Minorities and/or Women ($40 - $125 MM in revenues)	15%	Interest only for 3 years; rate equal to 10-year Treasury note	Yes
Small Business Owned by Minorities and/or Women (<$40 MM in revenues)	25%	Interest only for 5 years; rate equal to 10-year Treasury note	Yes

disaggregated in the future, which could stimulate the secondary market in spectrum to which we alluded before.

- *It created a class of applicants known as Designated Entities and set aside frequency blocks C and F for the DEs.* These are called the Entrepreneurs' Blocks. Table 5 outlines the four categories of DEs and the bidding credits, installment payment plans, and tax certificates to which they are entitled. Elaborate eligibility guidelines covering the size of the firms and their ownership are set forth in order to prevent abuse of the privileges offered to DEs. The Entrepreneurs' Blocks were created to fulfill the Congressional mandate of providing opportunities for small businesses, women- and minority-owned firms, and rural telephone companies.

- *It groups the A and B blocks into one auction, the C and F blocks into a second auction, and the D and E blocks into a third auction. Recent reports indicate that the FCC has restructured this initial arrangement, and will auction the C block by itself.* It is considering grouping the F block with the D and E auction, since they are all 10 MHz, or possibly auctioning the F block by itself. The rationale behind the groupings is to offer similar licenses simultaneously, so that information from the bids in on one license can be used in others. Also, by putting the C and F auction after the A and B auction, it allows Designated Entities to seek partnerships with unsuccessful bidders from the first round.

- *It specifies that simultaneous, multiple-round auctions will be used to award the licenses.* An overriding goal of the FCC is to put the license in the hands of the entity that values it the most, thereby generating the most revenue for the government and leaving little, if anything on the table for speculators. The FCC reasoned that the value of a given license is interdependent with that of other licenses that may be aggregated. Sequential auctions (one license at a time) were rejected as ineffective in allowing aggregation of interdependent licenses by those that would value them most. A simultaneous stopping rule was adopted to determine the end of the auction. For practical purposes, this means that all of the licenses to be auctioned at a given time (e.g., A and B) will be available for bidding, until no more bids are received on any of the blocks. Since this could lead to very long auctions, bidding activity rules and minimum bidding increments were established.

There are more rules on applications, down payments, number of rounds, penalties for withdrawal of bids, and so on, but these four points cover the most important issues. Table 6 shows the current top bidders for the A and B block licenses. The results to date from the first auction, which through round 76 has generated $5.5 billion in revenue (not including another $500 million or so from Pioneers' Preference winners), seem to indicate that the FCC rules have worked to encourage high bidding.

Two (and possibly three if the F block is auctioned alone) more auctions remain, with the C block auction due to start on April 17, 1995. As of this writing, a list of applicants is not available. These will not be household names as in the first auction, but rather smaller, privately held entrepreneurial firms. Look for losers in the MTA auction to team up as deep-pocketed financial partners with DEs. In the third auction for the 10 MHz blocks, anticipate cellular carriers bidding in-region to augment their 25 MHz of cellular spectrum and MTA winners doing the same.

The Build-Out of a PCS Network

Once a company has acquired PCS spectrum, it must build a network of cell sites and transmission equipment to link the sites to switches, which in turn, must be linked to the public switched telephone network. Savvy companies have been scouting cell-site locations since well before the auctions began. Radio frequency planning has been conducted to determine how many cells are needed and where they should optimally be located. Backup locations have been identified. Radio frequency engineers are being retained, as this talent will be in short supply with everyone trying to set up their networks at the same time.

An important issue is that of microwave relocation. The bands of spectrum being auctioned are currently being used for point-to-point microwave links. These incumbents must be relocated, at the PCS winners' expense. We have seen figures indicating that each link could cost up to $100,000 to relocate. So depending on how many links are in a

Table 6
High Bidders for MTA Blocks: Round 76, February 15, 1995

	Market	Freq	Round	Bid Amount	Price Per POP	Name
M001	New York	B	74	442,712,000	16.76	WirelessCo, L.P.
M002	Los Angeles	B	76	367,500,000	19.20	Pacific Telesis Mobile Service
M003	Chicago	A	75	372,750,000	30.88	AT&T Wireless PCS Inc.
M003	Chicago	B	76	355,573,362	29.46	WirelessCo, L.P.
M004	San Francisco	A	75	130,000,000	10.93	ALAACR Communications, Inc.
M004	San Francisco	B	33	132,000,943	11.10	Pacific Telesis Mobile Service
M005	Detroit	A	36	81,177,000	8.12	AT&T Wireless PCS Inc.
M005	Detroit	B	44	78,101,277	7.81	WirelessCo, L.P.
M006	Charlotte	A	39	66,616,000	6.83	AT&T Wireless PCS Inc.
M006	Charlotte	B	41	70,907,001	7.27	BellSouth Personal Communicati
M007	Dallas-Fort Worth	A	74	68,489,000	7.06	WirelessCo, L.P.
M007	Dallas-Fort Worth	B	69	68,601,000	7.08	PCS PRIMECO, L.P.
M008	Boston	A	50	121,660,000	12.87	AT&T Wireless PCS Inc.
M008	Boston	B	57	127,065,892	13.44	WirelessCo, L.P.
M009	Philadelphia	A	36	80,951,000	9.07	AT&T Wireless PCS Inc.
M009	Philadelphia	B	37	84,995,012	9.52	PhillieCo, L.P.
M010	Washington D.C.	B	76	201,686,333	25.93	American Portable Telecommunic
M011	Atlanta	A	76	140,698,483	20.27	GTE Macro Communications Corpo
M011	Atlanta	B	75	137,795,000	19.85	AT&T Wireless PCS Inc.
M012	Minneapolis	A	76	30,586,333	5.11	American Portable Telecommunic
M012	Minneapolis	B	75	29,395,000	4.91	Continental Cablevision, Inc.
M013	Tampa	A	56	81,420,000	15.03	PCS PRIMECO, L.P.
M013	Tampa	B	65	80,554,892	14.87	WirelessCo, L.P.
M014	Houston	A	76	75,932,536	14.63	PCS PRIMECO, L.P.
M014	Houston	B	75	74,991,000	14.45	WirelessCo, L.P.
M015	Miami	A	71	103,201,135	20.09	PCS PRIMECO, L.P.
M015	Miami	B	71	108,255,000	21.08	WirelessCo, L.P.
M016	Cleveland	A	70	77,158,000	15.60	Ameritech Wireless Communicati
M016	Cleveland	B	71	77,896,000	15.75	AT&T Wireless PCS Inc.
M017	New Orleans	A	69	69,959,000	14.20	WirelessCo, L.P.
M017	New Orleans	B	68	71,795,007	14.58	PCS PRIMECO, L.P.
M018	Cincinnati	A	76	29,795,002	6.32	GTE Macro Communications Corpo
M018	Cincinnati	B	75	28,915,000	6.13	AT&T Wireless PCS Inc.
M019	St. Louis	A	76	69,479,000	14.90	WirelessCo, L.P.
M019	St. Louis	B	76	66,541,872	14.27	PCS PRIMECO, L.P.
M020	Milwaukee	A	76	37,065,000	8.16	WirelessCo, L.P.
M020	Milwaukee	B	76	38,958,000	8.58	WirelessCo, L.P.
M021	Pittsburgh	A	74	19,175,367	4.67	American Portable Telecommunic
M021	Pittsburgh	B	76	20,163,001	4.91	CCI Data, Inc.
M022	Denver	A	67	26,750,483	6.89	GTE Macro Communications Corpo
M022	Denver	B	49	27,479,023	7.08	WirelessCo, L.P.
M023	Richmond	A	58	33,652,000	8.75	AT&T Wireless PCS Inc.
M023	Richmond	B	52	33,045,045	8.59	PCS PRIMECO, L.P.
M024	Seattle	A	76	62,155,030	16.24	Western PCS Corporation
M024	Seattle	B	75	61,442,000	16.05	WirelessCo, L.P.
M025	Puerto Rico	A	46	56,899,000	15.70	AT&T Wireless PCS Inc.
M025	Puerto Rico	B	47	54,672,000	15.09	Centennial Cellular Corp.
M026	Louisville	A	69	20,424,000	5.74	AT&T Wireless PCS Inc.
M026	Louisville	B	68	21,335,000	6.00	WirelessCo, L.P.

Table 6
High Bidders for MTA Blocks: Round 76, February 15, 1995 continued

Market		Freq	Round	Bid Amount	Price Per POP	Name
M027	Phoenix	A	74	50,500,002	14.39	GTE Macro Communications Corpo
M027	Phoenix	B	76	53,022,000	15.11	AT&T Wireless PCS Inc.
M028	Memphis	A	76	29,216,005	8.43	Southwestern Bell Mobile Syste
M028	Memphis	B	75	27,563,000	7.95	PCS PRIMECO, L.P.
M029	Birmingham	A	76	27,891,001	8.60	Powertel PCS Partners, L.P.
M029	Birmingham	B	76	26,325,000	8.11	AT&T Wireless PCS Inc.
M030	Portland	A	76	19,796,030	6.47	Western PCS Corporation
M030	Portland	B	76	19,957,000	6.52	WirelessCo, L.P.
M031	Indianapolis	A	75	60,822,000	20.16	WirelessCo, L.P.
M031	Indianapolis	B	76	63,970,538	21.20	PCS PRIMECO, L.P.
M032	Des Moines	A	41	9,242,020	3.07	Western PCS Corporation
M032	Des Moines	B	42	10,373,985	3.45	WirelessCo, L.P.
M033	San Antonio	A	76	31,801,001	10.65	CCI Data, Inc.
M033	San Antonio	B	74	31,826,628	10.66	PCS PRIMECO, L.P.
M034	Kansas City	A	73	12,022,888	4.13	American Portable Telecommunic
M034	Kansas City	B	76	12,053,000	4.14	WirelessCo, L.P.
M035	Buffalo-Rochester	A	76	16,302,000	5.87	WirelessCo, L.P.
M035	Buffalo-Rochester	B	73	15,472,000	5.57	PCS America Limited Partnershi
M036	Salt Lake City	A	76	24,280,030	9.44	Western PCS Corporation
M036	Salt Lake City	B	74	22,200,483	8.63	GTE Macro Communications Corpo
M037	Jacksonville	A	70	28,589,000	12.57	Powertel PCS Partners, L.P.
M037	Jacksonville	B	72	28,601,500	12.57	PCS PRIMECO, L.P.
M038	Columbus	A	76	16,631,000	7.75	WirelessCo, L.P.
M038	Columbus	B	75	16,546,000	7.71	AT&T Wireless PCS Inc.
M039	El Paso-Albuquerque	A	38	5,558,020	2.63	Western PCS Corporation
M039	El Paso-Albuquerque	B	36	5,073,155	2.40	AT&T Wireless PCS Inc.
M040	Little Rock	A	65	6,552,892	3.19	WirelessCo, L.P.
M040	Little Rock	B	55	8,000,000	3.90	Southwestern Bell Mobile Syste
M041	Oklahoma City	A	59	7,181,020	3.82	Western PCS Corporation
M041	Oklahoma City	B	65	5,944,921	3.17	WirelessCo, L.P.
M042	Spokane-Billings	A	50	5,688,000	3.05	Poka Lambro Telephone Cooperat
M042	Spokane-Billings	B	51	5,073,001	2.72	WirelessCo, L.P.
M043	Nashville	A	76	12,829,000	7.26	AT&T Wireless PCS Inc.
M043	Nashville	B	75	12,388,000	7.01	WirelessCo, L.P.
M044	Knoxville	A	65	8,553,000	4.97	AT&T Wireless PCS Inc.
M044	Knoxville	B	56	10,083,000	5.86	BellSouth Personal Communicati
M045	Omaha	A	65	4,647,000	2.80	AT&T Wireless PCS Inc.
M045	Omaha	B	66	3,560,000	2.15	Cox Cable Communications, Inc.
M046	Wichita	A	65	4,393,000	3.91	AT&T Wireless PCS Inc.
M046	Wichita	B	27	4,901,343	4.36	WirelessCo, L.P.
M047	Honolulu	A	76	9,749,333	8.80	American Portable Telecommunic
M047	Honolulu	B	75	9,924,000	8.95	AT&T Wireless PCS Inc.
M048	Tulsa	A	68	11,319,102	10.32	WirelessCo, L.P.
M048	Tulsa	B	66	11,029,789	10.06	Southwestern Bell Mobile Syste
M049	Alaska	A	69	826,000	1.50	GCI Communication Corp.
M049	Alaska	B	65	1,265,000	2.30	Poka Lambro Telephone Cooperat
M050	Guam	A	67	107,000	0.61	Poka Lambro Telephone Cooperat
M050	Guam	B	65	88,000	0.50	Poka Lambro Telephone Cooperat
M051	American Samoa	A	76	185,001	3.94	Communications International C
M051	American Samoa	B	71	172,000	3.66	American Portable Telecommunic
				5,528,463,717	$ 9.64	= Avg For entire US

band, and whether the service the PCS winner plans to provide can coexist with these links, relocation can be expensive and time-consuming.

Much of a build-out plan is driven by the services the carrier plans to offer. If the plan is me-too cellular, outdoor macro-cells are called for. Plots of land and tower construction are needed. If the intention of the spectrum owner is local loop-type service, the build-out plan must integrate outdoor and indoor micro-cells. For these, cabinet-sized spaces within buildings and at street level need to be secured. Regardless of the offering, a lot of capital must be invested in infrastructure before the first customer can be signed onto the system. *The practical implication of this is that operators will try to coordinate the rollout of service with the building of the network.*

An example will help illustrate the point. Say an operator wins the New York MTA. It will study the market potential for its service on a block-by-block-basis. The demographic characteristics of the Upper East Side, a wealthy neighborhood, will lead them to conclude that many potential customers can afford a new wireless service. The above-average level of education will point toward a propensity to try new, innovative products. The density of the population (lots of high-rise apartment buildings) indicates that service can be initiated without too many cells. Additional cells can be added as demand dictates. Therefore, capital investment can be targeted at the areas most likely to generate substantial revenue in the shortest possible time. In this manner, capital expenditure can be more closely matched to the cash flow, increasing the net present value of the business.

An option that some companies, particularly DEs, may choose, is to outsource their build-out entirely by leasing capacity on another company's network. AT&T Network Systems (AT&T's equipment arm, not its wireless service division) and Cable & Wireless have come together in a venture called North American Wireless to provide just this type of service. Many of the local exchange carriers have set up marketing efforts to sell network services to PCS providers. Bell Atlantic, for example, is willing to provide everything from soup to nuts to a spectrum holder to get its business up and running. The licensee can do as little or as much as it wants, and purchase the rest of its requirements from Bell Atlantic. Six of the RBOCs and GTE have formed a marketing support group called Unibridge, to provide what is basically a referral service for PCS players seeking operational support and network services from the LECs.

What is imperative for all players is speed, no matter what service they plan to offer or what technology they plan to use. Getting to market first with a new service can give a great advantage over competitors, perhaps preempting them from even trying. With so much capital invested in spectrum and build-out, the loading of customers quickly is crucial to recouping the investment. Until an operation reaches cash flow break-even penetration levels, additional investment in the form of operating losses is to be expected. The faster one can reach break-even, the better chance one has of surviving. Make no mistake, there will be plenty of crash-and-burn situations in PCS. Firms that overestimate demand or their marketing prowess may find themselves unable to reach break-even levels, burn through their equity, and go bankrupt.

Technology Choices: GSM Versus CDMA

One of the most important decisions for a PCS operator is which technology standard to use in the build-out. Standards are important in allowing interoperability among different wireless systems. Interoperability allows a customer to roam throughout various operators' systems using the same telephone handset. An analogy would be the ability to use a DOS program on any IBM-compatible computer. If one tried that program on an Apple computer, it would not work.

The two main rivals for digital wireless standards are the Global System for Mobile Communications (GSM) and Code Division Multiple Access (CDMA). The debate between the merits of these two could fill a entire report with techno-speak, so we will crystallize it into the salient points. The benefit of GSM is that it is the standard already employed in most of the countries outside the United States for digital cellular (800-900 MHz), particularly in western Europe. GSM has proven itself to be a very capable standard. Equipment manufacturers are producing handsets and infrastructure

equipment in quantity, an important requirement for getting to market rapidly. While GSM technology can conceivably be engineered to provide three times as much capacity as current analog cellular, this pales compared with the 10-20 times capacity envisioned with CDMA. (These are the *theoretical capabilities* of the two. In practice, European GSM operates at more like one times analog capacity, while CDMA may be in the 5 times analog range when initially rolled out.). However, there are no commercial CDMA systems operating anywhere in the world today.

The dilemma for operators becomes: Do I install GSM because it exists now, and because being first to market with an operating system is important to success; or do I hold out for CDMA, with its promise of increased capacity, but also the risk that it has not been proven in commercial operation and that the equipment may not be available in quantity? It is a very tough call, because once GSM is installed, it is difficult to switch to CDMA. If GSM is installed, and CDMA proves to be the better standard, the operator is stuck with a lower-capacity system. If CDMA does not pan out for several years, GSM adopters may have the jump in time to market.

The debate between the chief proponents, Ericsson for GSM and Qualcomm for CDMA, has taken on the tenor of a religious war. Each published technical "white papers" touting the benefits of its system over the other. For investors, it is too early in the debate to make a call about which will succeed. *We do not recommend making an investment decision based on which companies employ which standard.*

A Financial Perspective on PCS

The question we raised at the beginning of this report was: What makes the spectrum so valuable to PCS bidders? Our discussion of the rapid demand growth points up the multibillion dollar revenue potential. However, the enthusiasm must be tempered with a reasoned consideration of the difficulties in making PCS a viable business. The cost of acquiring customers and building the network must be weighed against the revenue potential. In the following section, we try to bring together these two forces to draw a conclusion about the worth of spectrum.

Cellular as a Starting Point for Thinking About the Value of PCS

Increasing wireless demand is a great thing to have, but it is no guarantee that PCS will be a gold mine. There is more to the picture. A few basic questions that come to mind are: What can be charged for the service, and how much does it cost to provide service? If it is too costly to provide the service, then it may not be as great a value as the volume growth seems to signal.

The cellular industry is an obvious place to find a touchstone with the value of wireless communications enterprises. The marketing and providing of PCS service should parallel those of cellular in many ways. In Table 7, we show our cellular industry valuation model. It is a detailed bottom-up methodology that estimates free cash flows and calculates their net present value. We will not discuss the model line by line, as it is fairly self-explanatory. However, a brief overview of the key inputs and outputs is called for.

The four main drivers of the free cash flow forecast are penetration rate, average revenue per user, operating cash flow margin, and capital expenditures. In the year 2004, we estimate that penetration will be 32%, average revenue per user will be $47, and operating cash flow margins will be 42%. We believe that average minutes of use will double as the cost per minute declines. In ten years, we figure that a minute of use will cost $0.19, which is 70% less in real terms than it is today. After 2000, we think that operating cash flow margins will decline into the low-40% range as the effects of competition are felt. It is our thesis that in ten years, a minute of airtime will be standardized and commoditized, and extra margin will be given to the consumer as carriers seek market share and the resulting economies of scale.

We believe that the business will be very competitive as new providers and technologies come on line. The competition will force cellular carriers to keep marketing expenses per gross subscriber addition fairly high, as the battle for customer attention in the distribution channels gets intense. Another important impact of competition, which we attempt to model, is that capital expenditures will stay around

Table 7
Cellular Industry Free Cash Flow Model
$ in millions

	1991	1992	1993	1994	1995 E	1996 E	1997 E
Subscriber Growth							
Gross Subscriber Growth (%)	69.4%	70.6%	69.1%	69.6%	64.2%	48.0%	37.4%
Monthly churn rate	2.2%	2.1%	2.0%	1.8%	1.8%	1.8%	1.7%
Disconnects as % of previous period	26.4%	24.6%	24.0%	21.6%	21.6%	21.0%	20.4%
Gross Subscriber Additions	3,668,820	5,334,663	7,624,569	11,145,506	15,207,423	16,229,832	16,052,313
Number of disconnects	1,394,727	1,859,058	2,647,861	3,458,044	5,118,535	7,095,020	8,755,807
Net Subscriber Additions	**2,274,093**	**3,475,605**	**4,976,708**	**7,687,462**	**10,088,888**	**9,134,812**	**7,296,506**
Growth in Net Adds	28%	53%	43%	54%	31%	-9%	-20%
Total Subscribers	**7,557,148**	**11,032,753**	**16,009,461**	**23,696,923**	**33,785,811**	**42,920,623**	**50,217,129**
Net Subscriber growth (%)	43.0%	46.0%	45.1%	48.0%	42.6%	27.0%	17.0%
US Population (000)	250.0	252.5	255.0	257.6	260.2	262.8	265.4
Implied penetration rate (%)	**3.02%**	**4.37%**	**6.28%**	**9.20%**	**12.99%**	**16.34%**	**18.92%**
Incremental Penetration		1.35%	1.91%	2.92%	3.79%	3.35%	2.59%
Revenue Composition							
Base Monthly Rate (w/30 mins)	$32	$32	$32	$31	$29	$28	$26
Average Revenue Per Min (>30)	$0.40	$0.38	$0.37	$0.34	$0.31	$0.28	$0.26
Average Minutes Per Month	137	132	126	130	139	149	159
% subs using vertical svcs	6%	8%	10%	13%	16%	19%	22%
Avg vert svc rev/mo by using subs	$14	$13	$13	$12	$11	$11	$10
Average Revenue Per User (ARPU)	**$75.63**	**$71.83**	**$68.83**	**$66.62**	**$64.66**	**$63.57**	**$61.48**
Change in ARPU		-5.0%	-4.2%	-3.2%	-2.9%	-1.7%	-3.3%
Avg Subscribers (000)	6,193	8,947	13,023	19,084	27,732	37,440	45,839
Other Revenues ($ millions)	73	107	152	223	304	325	321
Total Service Revenues (mils $)	**5,709**	**7,823**	**10,892**	**15,480**	**21,822**	**28,885**	**34,138**
Change in Revenue(%)	25.5%	37.0%	39.2%	42.1%	41.0%	32.4%	18.2%
Memo: Cents Per Minute	$ 0.55	$ 0.54	$ 0.55	$ 0.51	$ 0.46	$ 0.43	$ 0.39
Cost of Service							
Interconnect	305	412	556	815	1,229	1,723	2,189
Cost per minute of use	$ 0.030	$ 0.029	$ 0.028	$ 0.027	$ 0.027	$ 0.026	$ 0.025
Operating direct expenses	665	813	1,003	1,238	1,680	2,201	2,390
As % of revenue	11.65%	10.39%	9.21%	8.00%	7.70%	7.62%	7.00%
Total Costs of Services	**970**	**1,225**	**1,559**	**2,054**	**2,910**	**3,924**	**4,579**
As % of revenue	17.00%	15.66%	14.31%	13.27%	13.33%	13.58%	13.41%
Memo: Cents Per Minute	$ 0.10	$ 0.09	$ 0.08	$ 0.07	$ 0.06	$ 0.06	$ 0.05
Marketing & Selling							
Sales Commissions-Indirect	234	533	1,001	1,630	2,281	2,455	2,007
Percentage Indirect Sales	15%	25%	35%	45%	50%	55%	50%
Commission / Indirect New Sub	$425	$400	$375	$325	$300	$275	$250
Sales Commissions-Direct	236	287	341	408	492	464	493
Percentage Direct Sales	85%	75%	65%	55%	50%	45%	50%
Commission / Direct New Sub	$76	$72	$69	$67	$65	$64	$61
Other marketing expense	685	900	1,198	1,703	2,400	3,177	3,584
As % of revenue	12.00%	11.50%	11.00%	11.00%	11.00%	11.00%	10.50%
Total Marketing & Selling	**1,155**	**1,720**	**2,540**	**3,741**	**5,173**	**6,096**	**6,084**
As % of revenue	20.23%	21.99%	23.32%	24.17%	23.71%	21.11%	17.82%
Memo: Per Gross Add	$ 315	$ 323	$ 333	$ 336	$ 340	$ 376	$ 379

Table 7
Cellular Industry Free Cash Flow Model continued

	1998 E	1999 E	2000 E	2001 E	2002 E	2003 E	2004 E	CAGR '94-'04
	33.8%	30.2%	28.6%	27.0%	25.4%	24.4%	22.5%	
	1.7%	1.6%	1.6%	1.5%	1.5%	1.5%	1.4%	
	19.8%	19.2%	18.6%	18.0%	17.4%	17.4%	16.2%	
	16,973,390	17,288,753	18,173,800	18,872,792	19,352,301	20,077,631	19,810,204	5.9%
	9,942,992	10,991,525	11,819,324	12,581,861	13,257,088	14,317,655	14,263,347	15.2%
	7,030,398	6,297,228	6,354,475	6,290,931	6,095,213	5,759,976	5,546,857	
	-4%	-10%	1%	-1%	-3%	-6%	-4%	
	57,247,527	63,544,755	69,899,230	76,190,161	82,285,374	88,045,350	93,592,207	14.7%
	14.0%	11.0%	10.0%	9.0%	8.0%	7.0%	6.3%	
	268.0	270.7	273.4	276.2	278.9	281.7	284.5	1.0%
	21.36%	23.47%	25.56%	27.59%	29.50%	31.25%	32.89%	
	2.44%	2.11%	2.09%	2.02%	1.91%	1.75%	1.64%	
	$24	$22	$21	$19	$18	$17	$15	-6.7%
	$0.24	$0.21	$0.20	$0.18	$0.16	$0.15	$0.13	-8.9%
	170	182	195	209	223	239	256	7.0%
	25%	25%	25%	25%	26%	27%	28%	
	$10	$9	$8	$8	$7	$7	$7	-6.3%
	$59.46	$57.23	$54.96	$52.92	$51.05	$49.25	$47.53	-3.3%
	-3.3%	-3.7%	-4.0%	-3.7%	-3.5%	-3.5%	-3.5%	
	53,029	59,766	66,087	72,416	78,628	84,589	90,264	16.8%
	339	346	363	377	387	402	396	5.9%
	38,175	41,393	43,953	46,368	48,553	50,394	51,877	12.9%
	11.8%	8.4%	6.2%	5.5%	4.7%	3.8%	2.9%	
$	0.35	$ 0.31	$ 0.28	$ 0.25	$ 0.23	$ 0.21	$ 0.19	-9.6%
	2,628	3,075	3,529	4,013	4,523	5,050	5,593	21.2%
$	0.024	$ 0.024	$ 0.023	$ 0.022	$ 0.021	$ 0.021	$ 0.020	-3.0%
	2,481	2,691	2,901	3,153	3,399	3,654	3,891	12.1%
	6.50%	6.50%	6.60%	6.80%	7.00%	7.25%	7.50%	
	5,110	5,765	6,430	7,166	7,921	8,703	9,484	16.5%
	13.39%	13.93%	14.63%	15.45%	16.31%	17.27%	18.28%	
$	0.05	$ 0.04	$ 0.04	$ 0.04	$ 0.04	$ 0.04	$ 0.03	-6.8%
	1,719	1,383	1,381	1,255	1,185	1,230	1,040	-4.4%
	45%	40%	38%	38%	35%	35%	30%	
	$225	$200	$200	$175	$175	$175	$175	-6.0%
	555	594	619	619	642	643	659	4.9%
	55%	60%	62%	62%	65%	65%	70%	
	$59	$57	$55	$53	$51	$49	$48	-3.3%
	3,817	4,139	4,615	5,101	5,584	6,047	6,485	14.3%
	10.00%	10.00%	10.50%	11.00%	11.50%	12.00%	12.50%	
	6,091	6,116	6,616	6,975	7,411	7,920	8,184	8.1%
	15.96%	14.78%	15.05%	15.04%	15.26%	15.72%	15.78%	
$	359	$ 354	$ 364	$ 370	$ 383	$ 394	$ 413	2.1%

Table 7
Cellular Industry Free Cash Flow Model continued

	1991	1992	1993	1994	1995 E	1996 E	1997 E
General & Administrative							
Customer care	372	537	625	802	1,082	1,387	1,613
$ per month/sub	$5.00	$5.00	$4.00	$3.50	$3.25	$3.09	$2.93
Bad debt expense	171	235	327	464	655	867	1,024
As a % of revenue	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Billing expense	297	429	547	802	1,048	1,274	1,404
$ per month/sub	$4.00	$4.00	$3.50	$3.50	$3.15	$2.84	$2.55
Other expenses	742	978	1,307	1,780	2,510	3,177	3,414
As a % of revenue	13.00%	12.50%	12.00%	11.50%	11.50%	11.00%	10.00%
Total G&A Expense	**1,582**	**2,179**	**2,806**	**3,848**	**5,294**	**6,705**	**7,455**
As a % of revenue	27.72%	27.85%	25.76%	24.86%	24.26%	23.21%	21.84%
Net Equipment Subsidy							
Equipment Revenues	917	1,200	1,525	2,006	2,737	2,840	2,568
$ per handset/gross add	$ 250	$ 225	$ 200	$ 180	$ 180	$ 175	$ 160
Equipment Costs	1,192	1,680	2,287	3,009	4,106	4,260	3,853
As a % of revenue	130%	140%	150%	150%	150%	150%	150%
Total Equipment Subsidy	**275**	**480**	**762**	**1,003**	**1,369**	**1,420**	**1,284**
As a % of revenue	4.8%	6.1%	7.0%	6.5%	6.3%	4.9%	3.8%
Memo: Per Gross Add	$ 75	$ 90	$ 100	$ 90	$ 90	$ 88	$ 80
Depreciation & Cap Ex							
Cap Ex per Net New Sub ($)	$1,051	$745	$539	$525	$600	$675	$675
Cap Ex for repair, replacement, upgrad	$0	0	0	175	228	317	785
Total Capital Expenditures	**2,390**	**2,591**	**2,684**	**4,211**	**6,282**	**6,483**	**5,710**
Retirement of Plant & Equip	0	0	0	0	628	648	571
Total Capital Investment	8,672	11,262	13,946	18,158	23,811	29,646	34,785
Depreciation Expense	**1,000**	**1,296**	**1,639**	**2,087**	**2,728**	**3,475**	**4,027**
(Accumulated Depreciation)	4,000	5,296	6,934	9,021	11,121	13,947	17,403
Net Capital Investment	4,672	5,966	7,012	9,137	12,690	15,699	17,382
Depreciation Rate	13.0%	13.0%	13.0%	13.0%	13.0%	13.0%	12.5%
As % of revenue	17.5%	16.6%	15.0%	13.5%	12.5%	12.0%	11.8%
Growth in Capital Investment	na	30%	24%	30%	31%	25%	17%
Growth in Subs	na	46%	45%	48%	43%	27%	17%
Growth in MOU	na	39%	39%	51%	55%	44%	31%
Memos:							
Total Capital Inv per Minute of Use	$ 0.85	$ 0.79	$ 0.71	$ 0.61	$ 0.51	$ 0.44	$ 0.40
Capex per Incremental Minute	na	$ 0.65	$ 0.49	$ 0.42	$ 0.38	$ 0.32	$ 0.28
OPERATING INCOME	726	922	1,586	2,748	4,348	7,265	10,709
OPERATING CASH FLOW	1,726	2,218	3,225	4,835	7,076	10,740	14,736
TOT OP COSTS/AVG SUB	$599	$573	$530	$505	$482	$447	$395
OPERATING MARGIN	12.7%	11.8%	14.6%	17.8%	19.9%	25.2%	31.4%
OPER CASH FLOW MARGIN	30.2%	28.4%	29.6%	31.2%	32.4%	37.2%	43.2%

Table 7
Cellular Industry Free Cash Flow Model continued

	1998 E	1999 E	2000 E	2001 E	2002 E	2003 E	2004 E	CAGR
	1,773	1,899	1,994	2,076	2,141	2,189	2,219	10.7%
	$2.79	$2.65	$2.51	$2.39	$2.27	$2.16	$2.05	-5.2%
	1,145	1,242	1,319	1,391	1,457	1,512	1,556	12.9%
	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	
	1,542	1,652	1,735	1,806	1,863	1,904	1,930	9.2%
	$2.42	$2.30	$2.19	$2.08	$1.97	$1.88	$1.78	-6.5%
	3,817	4,139	4,395	4,637	4,855	5,039	5,188	11.3%
	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	
	8,278	**8,931**	**9,443**	**9,910**	**10,316**	**10,644**	**10,893**	**11.0%**
	21.69%	21.58%	21.48%	21.37%	21.25%	21.12%	21.00%	
	2,546	2,420	2,453	2,453	2,419	2,409	2,377	1.7%
$	150	$ 140	$ 135	$ 130	$ 125	$ 120	$ 120	-4.0%
	3,819	3,631	3,680	3,680	3,629	3,614	3,566	1.7%
	150%	150%	150%	150%	150%	150%	150%	
	1,273	**1,210**	**1,227**	**1,227**	**1,210**	**1,205**	**1,189**	**1.7%**
	3.3%	2.9%	2.8%	2.6%	2.5%	2.4%	2.3%	
$	75	$ 70	$ 68	$ 65	$ 63	$ 60	$ 60	
	$625	$575	$525	$535	$550	$575	$575	0.9%
	869	909	907	881	846	804	739	13.9%
	5,263	**4,530**	**4,243**	**4,246**	**4,199**	**4,116**	**3,929**	**-0.7%**
	526	453	424	425	420	412	393	-5.1%
	39,522	43,599	47,418	51,240	55,018	58,723	62,259	13.1%
	4,458	**4,572**	**4,778**	**4,933**	**5,047**	**5,403**	**5,444**	**10.1%**
	21,335	25,454	29,808	34,316	38,944	43,935	48,986	18.4%
	18,187	18,145	17,610	16,924	16,075	14,788	13,272	3.8%
	12.0%	11.0%	10.5%	10.0%	9.5%	9.5%	9.0%	
	11.7%	11.0%	10.9%	10.6%	10.4%	10.7%	10.5%	
	14%	10%	9%	8%	7%	7%	6%	
	14%	11%	10%	9%	8%	7%	6%	
	24%	21%	18%	17%	16%	15%	14%	
$	0.36	$ 0.33	$ 0.31	$ 0.28	$ 0.26	$ 0.24	$ 0.22	
$	0.25	$ 0.20	$ 0.18	$ 0.16	$ 0.14	$ 0.13	$ 0.11	
	12,964	14,798	15,459	16,158	16,648	16,520	16,684	19.8%
	17,422	19,370	20,238	21,091	21,695	21,923	22,129	16.4%
	$367	$348	$340	$332	$326	$322	$316	-4.6%
	34.0%	35.8%	35.2%	34.8%	34.3%	32.8%	32.2%	
	45.6%	46.8%	46.0%	45.5%	44.7%	43.5%	42.7%	

Table 7
Cellular Industry Free Cash Flow Model continued

	1995 E	1996 E	1997 E	1998 E	1999 E	2000 E	2001 E	2002 E	2003 E	2004 E	CAGR
Operating Cash Flow	7,076	10,740	14,736	17,422	19,370	20,238	21,091	21,695	21,923	22,129	16.4%
- Depreciation	2,728	3,475	4,027	4,458	4,572	4,778	4,933	5,047	5,403	5,444	10.1%
= Unlevered Pretax Income	4,348	7,265	10,709	12,964	14,798	15,459	16,158	16,648	16,520	16,684	19.8%
- Taxes @ 36%	1,565	2,616	3,855	4,667	5,327	5,565	5,817	5,993	5,947	6,006	
= Unlevered Net Income	2,783	4,650	6,853	8,297	9,471	9,894	10,341	10,655	10,573	10,678	19.8%
+ Depreciation	2,728	3,475	4,027	4,458	4,572	4,778	4,933	5,047	5,403	5,444	10.1%
- Capital Expenditures	6,282	6,483	5,710	5,263	4,530	4,243	4,246	4,199	4,116	3,929	-0.7%
- Increase in Working Capital	317	353	263	202	161	128	121	109	92	74	
= Unlevered Free Cash Flow	(1,088)	1,288	4,906	7,290	9,351	10,301	10,907	11,394	11,768	12,119	NM
Growth of Unlevered net income	58.2%	67.1%	47%	21.1%	14.2%	4.5%	4.5%	3.0%	-0.8%	1.0%	
Growth of Capital Expenditures	49.2%	3.2%	-11.9%	-7.8%	-13.9%	-6.3%	0.1%	-1.1%	-2.0%	-4.5%	
Growth of Unlevered free cash flow	83%	-218%	281%	49%	28%	10%	6%	4%	3%	3%	

Table 8
Cellular Industry Net Present Value Summary
$ in millions, except per-POP prices

Unlevered After-Tax Free Cash Flows						
Year	FCF	% Chng	Year	FCF	% Chng
1995	$ (1,088)	-	2000	$ 10,301	10%
1996	$ 1,288	-218%	2001	$ 10,907	6%
1997	$ 4,908	281%	2002	$ 11,394	4%
1998	$ 7,290	49%	2003	$ 11,768	3%
1999	$ 9,351	28%	2004	$ 12,119	3%

	Discount Rates	Growth Rate of Terminal Free Cash Flow 5%	6%	7%	8%
NPV of Cash Flows Through 2004	12.0%	$ 36,389	$ 36,389	$ 36,389	$ 36,389
	12.5%	35,352	35,352	35,352	35,352
	13.0%	34,352	34,352	34,352	34,352
	13.5%	33,387	33,387	33,387	33,387
	14.0%	32,457	32,457	32,457	32,457
NPV of Terminal Value	12.0%	$ 58,531	$ 68,937	$ 83,504	$ 105,356
	12.5%	52,249	60,861	72,606	89,570
	13.0%	46,859	54,063	63,668	77,116
	13.5%	42,196	48,279	56,232	67,078
	14.0%	38,139	43,315	49,970	58,844
Terminal Value As a Multiple of Terminal OCF	12.0%	8.2	9.7	11.7	14.8
	12.5%	7.7	8.9	10.7	13.1
	13.0%	7.2	8.3	9.8	11.8
	13.5%	6.8	7.7	9.0	10.8
	14.0%	6.4	7.3	8.4	9.9
Private Market Enterprise Value	12.0%	$ 94,920	$ 105,325	$ 119,893	$ 141,744
	12.5%	87,601	96,213	107,957	124,921
	13.0%	81,211	88,415	98,020	111,468
	13.5%	75,585	81,667	89,620	100,465
	14.0%	70,596	75,772	82,427	91,300
Enterprise Value Per POP	12.0%	$ 184	$ 204	$ 233	$ 275
	12.5%	170	187	210	242
	13.0%	158	172	190	216
	13.5%	147	159	174	195
	14.0%	137	147	160	177
Enterprise Value As A Multiple Of 1995 OCF	12.0%	13.4	14.9	16.9	20.0
	12.5%	12.4	13.6	15.3	17.7
	13.0%	11.5	12.5	13.9	15.8
	13.5%	10.7	11.5	12.7	14.2
	14.0%	10.0	10.7	11.6	12.9

Most Reasonable Valuation Range		
Steady State Growth:	6.0%	7.0%
Discount Rate:	13.0%	13.0%
Implied intrinsic value:		
Total value (mil.)	88,415	98,020
Total value per POP	$ 172	$ 190

$500 per net new subscriber. The addition of capacity-enhancing technology and the need continuously to improve service quality and choice will keep spending high. Witness the long-distance industry, where increasing capex is a must to maintain share.

In Table 8, we summarize our net present value analysis of the cellular industry. We conclude that on average (urban, rural, etc.), the U.S. cellular industrys is worth $172-190 per POP, or a total enterprise value of $88-98 billion dollars. Note that a significant majority of the total value is derived from free cash flows coming after 2004, namely the terminal value in our table. The implication of the back-end-loaded cash flow pattern is that values are extremely sensitive to discount and long-term growth rates.

PCS Bidding Methodology

Bidders in the PCS auction went through a process similar to our cellular valuation—but in excruciating detail—to estimate how high they could bid for spectrum. We have seen some of these models, and the number of inputs is truly staggering. One actually had detail down to the janitor's 401(k) contribution! Table 9 presents a partial list of variables to be forecast by a bidder. Once the bidder has worked up these estimates, it calculates the net present value of the free cash flows that it thinks it can generate. That figure then becomes the most it will pay for the license. If, for example, this amount is $200 million for a particular MTA, and it bids that much and wins, its return equals the discount rate, provided the cash flow forecast is correct. If the license is acquired for only $150 million, then the potential rate of return will be above the discount rate.

Every bidder comes to the auction with its maximum limit in mind. This is what makes it imperative for companies to form consortia *before* the auction starts. It is critical to know what one's partner is bringing to the table in terms of existing spectrum, infrastructure, and distribution. These variables must be run through the models to adjust the maximum bid level. If one's partner has existing cell sites or telephone poles that can lower the cost of a build-out, the NPV of the license rises. If the partner is a cable company or a utility, it may bring fiber-optic cabling to the table, which will also lower the costs of build-out.

This need to calculate a maximum bid value has resulted in pretty tight control over information leading up to the auction. Any leak might give away an advantage that competitors can use in their modeling to raise their bids. Secrecy has been prevalent. In the narrowband PCS auction, the companies set up "war rooms" with heavy security to protect vital bidding strategies and computer models. Game-theory experts were consulted to devise strategies for outwitting opponents with feints and parries for this market, then that. However, once one cut through the gaming, the maximum bid one calculated was what one had to stick to, unless one was willing to accept lower rates of return.

A Framework for Valuing PCS Spectrum

Since the auction is still in progress, we do not yet have a fixed data point on what the companies think spectrum is worth, although we have a floor. *Therefore, we thought it would be a helpful exercise to test the reasonableness of the current bids and estimate what assumptions must be made to arrive at the current prices.* In the process, we have

Table 9
Partial List of Variables to Be Forecast by a PCS Bidder

market demand	interconnect charges	tax rates
population density	speed of build-out	handset costs
population growth	technology standard used	marketing costs
market share	size of cells	cost of capital
products offered	number of cells	debt-to-equity ratio
number of subscribers	cost per cell	infrastructure synergies
pricing plans	number of employees	competitive pressures
minutes of use	neighborhoods built out first	etc.,etc,.etc.

Table 10
PCS Discounted Cash Flow Analysis
$ in millions, except per-POP prices

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Population (000)	260,000	262,600	265,226	267,878	270,557	273,263	275,995	278,755	281,543	284,358
Coverage Percentage	10%	20%	40%	60%	80%	82%	84%	86%	88%	90%
Covered Population	26,000	52,520	106,090	160,727	216,446	224,075	231,836	239,729	247,758	255,922
Penetration Rate	0.0%	0.5%	0.8%	1.4%	2.4%	3.6%	5.3%	7.4%	9.6%	12.0%
Subscribers (000)	-	252	891	2,314	5,195	8,067	12,241	17,836	23,785	30,711
Net Additions	-	252	639	1,423	2,880	2,872	4,174	5,595	5,949	6,926
Growth in Subscribers			*254%*	*160%*	*124%*	*55%*	*52%*	*46%*	*33%*	*29%*
ARPU	$ -	$ 50.00	$ 48.13	$ 46.25	$ 44.38	$ 42.50	$ 40.63	$ 38.75	$ 36.88	$ 35.00
Revenues (millions)	-	76	330	890	1,999	3,382	4,950	6,993	9,209	11,444
Growth in Revenues			*336%*	*169%*	*125%*	*69%*	*46%*	*41%*	*32%*	*24%*
OCF Margin		-100%	-40%	-20%	0%	15%	25%	35%	40%	45%
OCF (millions)	(75)	(76)	(132)	(178)	-	502	1,237	2,448	3,683	5,150
Growth in OCF							*146%*	*98%*	*50%*	*40%*
Operating Cost per Avg Sub		*$ 1,200*	*$ 809*	*$ 666*	*$ 533*	*$ 434*	*$ 366*	*$ 302*	*$ 266*	*$ 231*
Capex Per Addt'l Covr'd POP	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20	$ 20
Capex Per Net Add	$ 500	$ 472	$ 444	$ 417	$ 389	$ 361	$ 333	$ 306	$ 278	$ 250
Capital Expenditures	520	649	1,355	1,686	2,234	1,190	1,547	1,867	1,813	1,895
Capex Per net Add		*$ 2,576*	*$ 2,121*	*$ 1,184*	*$ 776*	*$ 414*	*$ 371*	*$ 334*	*$ 305*	*$ 274*
Total Capital Investment	520	1,169	2,525	4,211	6,445	7,635	9,181	11,049	12,862	14,757
Depreciation	-	167	361	602	921	1,091	1,312	1,504	1,670	1,747
Accumulated Depreciation	-	167	528	1,129	2,050	3,141	4,452	5,956	7,627	9,374
Net Capital Investment	520	1,002	1,997	3,081	4,395	4,494	4,729	5,092	5,235	5,382
Spectrum Amortization	686	686	686	686	686	686	686	686	686	686
Free Cash Flow	(321)	(391)	(1,063)	(1,336)	(1,656)	(229)	(36)	487	1,392	2,277
Growth in Free Cash Flow		*22%*	*172%*	*26%*	*24%*	*-86%*	*-84%*	*-1467%*	*186%*	*64%*

VALUATION MATRIX

Enterprise Value - Terminal FCF Growing at:

WACC	6%	7%	8%
11%	15,171	19,622	27,040
12%	11,107	13,844	17,950
13%	8,304	10,109	12,635
14%	6,281	7,531	9,199
15%	4,773	5,672	6,828

Average Nationwide Per-POP Value for 30 MHz MTA:

WACC	6%	7%	8%
11%	17.51	22.64	31.20
12%	12.82	15.97	20.71
13%	9.58	11.66	14.58
14%	7.25	8.69	10.61
15%	5.51	6.54	7.88

Enterprise Value - OCF Exit Multiple of:

WACC	6.0	8.0	10.0
11%	9,053	12,680	16,308
12%	8,104	11,421	14,737
13%	7,249	10,283	13,317
14%	6,478	9,256	12,034
15%	5,782	8,328	10,874

Average Nationwide Per-POP Value for 30 MHz MTA:

WACC	6.0	8.0	10.0
11%	10.45	14.63	18.82
12%	9.35	13.18	17.00
13%	8.36	11.87	15.37
14%	7.47	10.68	13.89
15%	6.67	9.61	12.55

developed some sensitivity tables to use as a handy reference to track the bidding and see the implied assumptions needed to justify the bids.

The bidding for the A and B blocks is just over $5.5 billion dollars in total as of this writing. Add another $500 million that the Pioneers' Preference awardees must pay for their three markets, and we arrive at around $6 billion bid to date. While the A and B blocks represent 60 MHz of spectrum, or 50% of the total being auctioned, we hypothesize that these blocks represent more than half of the value. There are several reasons for this:

First and foremost, the biggest players in telecommunications will have virtually all the spectrum they want from the A and B auctions. Charts 1-3 show the potential combined cellular-PCS footprints of the three top national consortia. They are basically complete. Second, the winners of the As and Bs will probably capture the majority of the market share of PCS. Third, if one buys the argument that CDMA, or digital technology in general, has great capacity, the big players may not need the 10 MHz blocks still to be auctioned. Fourth, the remaining licenses are somewhat less appealing due to their smaller geographic size and narrower bandwidths. Finally, 40 of the remaining 60 MHz are reserved for Designated Entities, which are smaller, less well-heeled players that probably cannot afford to bid very high for the remaining licenses. If we assume that the A and B blocks together are worth 50% more than the remaining blocks combined, we get a 60/40 split in the relative values. Therefore, we hypothesize that the $6 billion bid to date indicates a total value of about $10 billion for all 120 MHz.

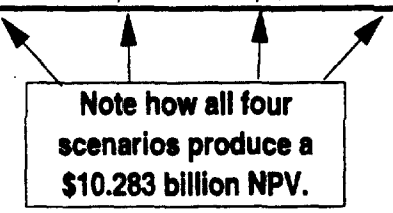
In Table 10, we show a skin-and-bones discounted cash flow model that uses the same primary value drivers as our cellular model to back into some assumptions that would justify the $10 billion figure. We present this as an intuitive framework for a sanity check on these prices. The reader should understand that the simplicity of the model has its weaknesses. For one, we do not try to distinguish between the types of service likely to be offered, namely "me-too" cellular or local loop replacement. Second, the vast majority of the enterprise value is generated in the years after 2004. We attempt to capture this by calculating a terminal value using a multiple of operating cash flow. We use an 8 times multiple for all the cases, since in our base-case scenario, this multiple roughly equates to a 7% long-term growth rate in free cash flows. This is about as high a growth assumption as we dare to make, given the likely competitive nature of the industry in ten years.

We start with the total U.S. population of 260 million, then multiply by the percentage covered by a 1900 MHz signal. Population coverage ramps up quickly as cities are built out, then slows by the year 2000 as less densely settled areas are covered. (Cellular coverage also progressed in this fashion. Ten years into cellular's existence, population coverage is in the high-90% range.) We then multiply by the penetration rate of PCS into the covered population. Our base assumptions are that PCS will achieve a 12% penetration of the covered population, or 10.8% of the total population. This gives around 30 million subscribers. Average revenue per user is then multiplied by average subscribers to get total revenues. We assume ARPU will start around $50, underpricing cellular, and then decline to $35 as it targets the landline customers of the local exchange carriers. Operating cash flow is derived by estimating an OCF margin, and multiplying by total revenue. Margins start negative, then rise to 45% in 2004, a level achieved by mature cellular operators ten years into their existence.

Capital expenditures are estimated using two criteria. The first is a dollar amount per additional covered pop. This factors in certain basic costs that are needed just to prepare the backbone of a system, regardless of the number of customers. For example, this might include such items as land, towers, fiber and microwave links, switches, interconnection facilities, computer systems, and the like. In the early years, this factor dominates the capex budget. The second criterion is a dollar amount per subscriber addition. This covers additional cell sites, microcells, customer support facilities, working capital, etc. This factor dominates the capex budget in the later years. The result of our base-case inputs is that capex per net add starts at about $2,600, then declines to around $275 in ten years.

Table 11
PCS Scenarios: Four Ways to $10 Billion
$ in millions

Variables:				
Penetration 2004	12.0%	30.0%	10.0%	12.0%
ARPU 2004	$ 35.00	$ 22.79	$ 50.00	$ 50.00
Margin 2004	45%	45%	33%	36%
Capex Additional Covrd POP	$ 20	$ 20	$ 10	$ 20
Capex Per Net Add 1995	$ 500	$ 500	$ 500	$ 500
Capex Per Net Add 2004	$ 250	$ 500	$ 200	$ 500
Result:				
NPV - 7% FCF Growth	10,109	(15,451)	11,814	3,252
NPV - 8x OCF Exit Multiple	10,283	10,283	10,283	10,283



From the capex figures, we calculate annual depreciation using a seven-year average life of capital equipment. We assume that the $10 billion purchase price of spectrum will be amortized over 15 years, straight line, and that taxes are 36%. We now have all the information to calculate free cash flow. To produce the $10 billion base-case figure, we take the net present value of the free cash flows. The valuation matrix below the table shows the sensitivities of net present value to discount rates and terminal value calculations.

The average nationwide per-POP value for an MTA is derived by multiplying the total NPV by 60%, the estimate of how much the MTAs represent of the total value of PCS. We then divide by two, since there are two MTAs, then divide by 260 million POPs in the entire United States. Clearly, there is a great divergence about this average, as some MTAs are regarded as better than others.

Another way to interpret the valuation matrix is the following: If the bidders pay $10.283 billion, and the free cash flows come through as projected, the PCS opportunity will produce a 13% return on invested capital. If bidders pay more than that, without getting higher free cash flows, the return will be below 13%. If they pay the $10 billion, and the cash flows are higher than our base case, the return on capital will be greater than 13%.

Interpretation of the Framework

The framework should be understood as a tool for scenario analysis, not as the definitive answer to the exact value of PCS spectrum. In Table 11, we show how four different sets of inputs can give the same $10 billion answer. Each of these scenarios represents a different vision for the future of PCS and wireless. Base case B assumes massive penetration of 30% through a low-price strategy. Maintenance of 45% margins is assumed, but higher capital expenditures eat up the increased revenue. In base case C, low penetration of 10% is mitigated by higher ARPU at $50 and a lower cost per net add to build out the system In base case D, penetration is 12%, but high monthly prices are offset by lower margins and higher capex. *What we are trying to illustrate is that a single-point NPV is a function of many variables.* In this case, one can think of a four-dimensional matrix of variables that all arrive at the same NPV. In reality, the matrix has hundreds of dimensions that must all be assumed to arrive at an NPV.

We show the resulting NPV using two methods of calculating terminal value. It is important to note that the high-capital-expenditure scenarios, B and D, crush the NPV using the growing-perpetuity methodology of calculating terminal value. This points up a weakness in the OCF-multiple method, since it ignores the capital needed to derive the revenue and operating cash flow. When the NPVs from the two methods are fairly close, as in cases A and C, we have more confidence in the values derived. When they diverge, we have less confidence. *The conclusion is that there is a huge amount of leverage in PCS values attached to the capital costs to build out the networks.*

Sensitivity of Spectrum Value to Changing Assumptions

In Table 12, we provide four sensitivity tables to allow the reader to track the bidding as it moves along. The tables show the NPV (using the 8 times OCF terminal value) of the entire 120 MHz of PCS, by holding the base case A assumptions constant, and changing only the two indicated variables. The line through the table represents the $10 billion value we estimate from the current level of bidding on the MTAs.

In the first table, ARPU and penetration are varied. The $10.283 billion value for base case A is represented at the intersection of the $35 ARPU column and the 12% penetration row. If bidding on the MTAs progresses to $10 billion, our logic implies a $16 billion total value for PCS. Referring to the table, we can see that this is justified by several scenarios—$30 ARPU and 22% penetration, $50 ARPU and 12% penetration, and so on. From the second table, we see that a $16 billion total can also be justified by raising ARPU to $40, and increasing the OCF margin in the year 2004 to 55%, assuming penetration is fixed at 12%.

Another way to use these tables is to estimate the upside potential from a given bid. Let us say, for example, that $10 billion is the final figure for the spectrum. If it comes to pass that penetration goes to 18% and ARPU levels to $45, then the realized value of the spectrum will be $22.165 billion, an increase in value of $12 billion! Another way to

Table 12
PCS Valuation Sensitivity Analysis
$ in millions

Average Revenue Per User in 2004

Penetration in 2004	$ 20.00	$ 25.00	$ 30.00	$ 35.00	$ 40.00	$ 45.00	$ 50.00
6%	1,484	2,512	3,539	4,567	5,594	6,622	7,649
8%	2,362	3,732	5,102	6,472	7,842	9,212	10,582
10%	3,240	4,953	6,665	8,378	10,090	11,803	13,515
12%	4,118	6,173	8,228	10,283	12,338	14,393	16,448
14%	4,996	7,394	9,791	12,189	14,586	16,984	19,381
16%	5,874	8,614	11,354	14,094	16,834	19,574	22,314
18%	6,752	9,835	12,917	16,000	19,082	22,165	25,247
20%	7,630	11,055	14,480	17,905	21,330	24,755	28,180
22%	8,508	12,276	16,043	19,811	23,578	27,345	31,113

Average Revenue Per User in 2004

OCF Margin in 2004	$ 20.00	$ 25.00	$ 30.00	$ 35.00	$ 40.00	$ 45.00	$ 50.00
25%	207	1,348	2,488	3,629	4,769	5,910	7,050
30%	1,185	2,554	3,923	5,292	6,662	8,031	9,400
35%	2,163	3,761	5,358	6,956	8,554	10,151	11,749
40%	3,141	4,967	6,793	8,620	10,446	12,272	14,099
45%	4,118	6,173	8,228	10,283	12,338	14,393	16,448
50%	5,096	7,380	9,663	11,947	14,230	16,514	18,798
55%	6,074	8,586	11,098	13,611	16,123	18,635	21,147

Terminal Value Based on a 8x OCF Multiple
Capex Per Net Add in 2004

Penetration in 2004	$ 150	$ 200	$ 250	$ 300	$ 350	$ 450	$ 500
6%	4,935	4,751	4,567	4,383	4,199	3,830	3,646
8%	6,963	6,718	6,472	6,227	5,981	5,490	5,245
10%	8,992	8,685	8,378	8,071	7,764	7,150	6,844
12%	11,020	10,652	10,283	9,915	9,547	8,810	8,442
14%	13,048	12,618	12,189	11,759	11,330	10,470	10,041
16%	15,076	14,585	14,094	13,603	13,112	12,130	11,639
18%	17,104	16,552	16,000	15,447	14,895	13,790	13,238
20%	19,133	18,519	17,905	17,291	16,678	15,450	14,837
22%	21,161	20,486	19,811	19,136	18,460	17,110	16,435

Terminal Value Based on a Growing Perpetuity
Capex Per Net Add in 2004

Penetration in 2004	$ 150	$ 200	$ 250	$ 300	$ 350	$ 450	$ 500
6%	6,985	6,044	5,104	4,163	3,223	1,342	402
8%	9,280	8,026	6,772	5,518	4,264	1,756	502
10%	11,575	10,008	8,440	6,873	5,306	2,171	603
12%	13,870	11,990	10,109	8,228	6,347	2,585	704
14%	16,166	13,971	11,777	9,583	7,388	3,000	805
16%	18,461	15,953	13,445	10,937	8,430	3,414	906
18%	20,756	17,935	15,114	12,292	9,471	3,828	1,007
20%	23,051	19,917	16,782	13,647	10,512	4,243	1,108
22%	25,347	21,898	18,450	15,002	11,554	4,657	1,209

look at these is to first estimate where one thinks ARPU, penetration, margins, or capex will end up, then look up the implied value one would pay for spectrum. If one can get it more cheaply than the NPV shown on the table, the returns will exceed the 13% cost of capital. By now, the idea should be clear.

The last two tables show the sensitivity of NPV to changes in capital expenditures per net additional subscriber and changes in penetration rate. The first table calculates NPV using a terminal value of 8 times operating cash flow in 2004. The second uses the traditional growing-perpetuity formula of $CF/(r-g)$, where CF is the free cash flow in 2004, r is the 13% discount rate, and g is the assumed 7% long-term growth rate in free cash flow. As we discussed above, the weakness of using a multiple of operating cash flow is that it ignores the effects of capital expenditures necessary to maintain the business. The reason we do not abandon this method entirely is its prevalence and popularity in the investment community as a shorthand methodology for valuation.

The weakness rears its ugly head in these two tables. The $10 billion line is almost straight across in the table using an OCF multiple, whereas it drops sharply in the table using a growing-perpetuity formula for terminal values. Which one makes more intuitive sense? To us, the answer is clear. In a capital-intensive business such as telecommunications, in which the fixed assets dominate the balance sheet, there should be huge leverage to capital expended. *Herein lies one of the most salient conclusions we can draw at this stage of the game. Capital expenditures per net subscriber added to a PCS network must come down substantially from where they are in cellular today ($500), or the economics of the business decays precipitously.*

Other Valuation Considerations

We think that the key inputs to our model are the primary drivers of net present value. However, what must be borne in mind is that this model derives broad theoretical averages for spectrum values.

There are subtle market- and company-specific considerations that can and do affect the bidding for spectrum. For the big telecommunications concerns involved in the bidding, there are impacts to their core businesses that could materially affect the worth of PCS spectrum. For example, a local exchange company may worry that the growth in its wireline franchise can slow if it does not get into the wireless business. There may be a cost to doing nothing. This could impel that company to pay more for spectrum in its home market than a player coming from the outside.

A wireline player employing wireless local loop applications in-region may be able to realize maintenance cost savings over copper loops. Ownership of or access to existing infrastructure in a given region allows a bidder to pay more for spectrum than someone without infrastructure. This includes distribution channels that can be leveraged to market new PCS products. A bidder can choose to lease capacity and resources from another entity, thereby avoiding up-front capital expenditures, which can lower the NPV. That bidder can also lower the risk that its business plan does not work out as well as envisioned. Relocation of microwave links that are resident in the bandwidth being auctioned can also greatly affect the price of PCS spectrum. In some markets, the cost of relocation in terms of dollars and delay in getting to market can rival the cost of the spectrum itself.

Strategy-specific considerations can govern the price of spectrum in a particular MTA or BTA. Take Chicago, for instance. The three entities pursuing national strategies—AT&T, PCS PrimeCo, and WirelessCo—do not own spectrum in Chicago, but all think that Chicago is imperative to assembling a national footprint, so the bidding in that city has been the most spirited of any MTA, and currently stands near $30 per POP. The added value of having a national footprint may be applied to the Chicago MTA, over and above its NPV on a standalone basis. On the other side of the coin is San Francisco. AT&T and PCS PrimeCo have cellular spectrum already, so only WirelessCo needs spectrum. Along with Pacific Telesis, which is focused in-region, they seem to have been able to minimize the intensity of the bidding for the two San Francisco licenses, which had been unchanged at $10-11 per POP since the thirty-third round of the auction, until Craig McCaw topped it in round 76. (Hence, the danger of writing this piece in the midst of the auction.)

Finally, differences in the cost of capital among firms can have a great impact on the bidding levels. The big players bidding for the MTAs have sizable revenue and income streams from core businesses with which to support debt ratings. This makes for lower capital costs and higher perceived NPVs of spectrum. Among the Designated Entities, the opposite is true. Many will be pure PCS plays, funded with venture-capital equity. The government financing available to DEs in terms of bidding credits, lower down payments, and installment payments will help mitigate the higher equity costs, but differences among players will affect how high they will bid.

Lessons for PCS, Think Long Term

For investors, the most important lesson that can be drawn from valuations for PCS is that *extremely long time horizons are needed to understand the values being paid today for spectrum*. In the near term, the tangible effects of PCS will be negative free cash flows and higher interest and depreciation expenses. These symptoms can have a negative perceptual effect on the stocks of companies with PCS investments, since many shareholders focus on short-term earnings results. Focusing short term is a mistake in evaluating a PCS investment. One must forecast long-term volume, pricing, and margins to justify investing in PCS today. We are the first to admit that making such forecasts is more art than science.

Investors should bear in mind that the future PCS business of the companies now bidding will be dwarfed by their basic telephone, cable, and cellular holdings. These are not pure plays on PCS. If one is a conservative investor, these companies will give some exposure to the upside of PCS. If one wants to make a leveraged bet on PCS, the companies that participate in the DE auctions may represent better opportunities, since a greater proportion of their holdings will be made up of PCS licenses. However, many are still in the venture-capital stage of evolution. It will be a few years before IPOs provide a universe of pure PCS plays for the public to invest in.

Table 13
Companies Mentioned in this Report with Current CS First Boston Ratings
closing price 2/16/95

AirTouch Communications	ATI	Not Rated	27 1/8
Ameritech Corp.	AIT	Hold	41 7/8
AT&T	T	Strong Buy	50 1/2
Bell Atlantic Corp.	BEL	Hold	52 1/8
BellSouth Corp.	BLS	Buy	58 1/2
Cable & Wireless	CWP	Hold	18
Comcast	CMCSA	Buy	15 3/4
Cox Cable	COX	Buy	16 7/8
Ericsson	ERICY	Hold	56 7/8
GTE Corp.	GTE	Buy	33
LIN Broadcasting Corp.	LINB	Hold	129 1/4
MCI Communications Corp.	MCIC	Strong Buy	19 1/2
MFS Communications Corp.	MFS	Not Rated	35 1/2
Nextel Communications Inc.	CALL	Not Rated	12
NYNEX	NYN	Buy	38 3/8
Pacific Telesis Group	PAC	Buy	29 3/4
Qualcomm Inc.	QCOM	Not Rated	25 1/2
SBC Communications	SBC	Buy	41 1/4
Sprint Corp.	FON	Buy	29 5/8
US West Inc.	USW	Hold	37 3/4